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Maryland Utility NO_x RACT Update Report

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Prepared under the direction of:

John Sherwell, Ph.D.
Maryland Power Plant Research Program

Prepared by:

Environmental Resources Management
2666 Riva Road
Annapolis, MD 21401

Prepared for:

Mayrland Power Plant Research Program
580 Taylor Avenue
Tawes State Office Building, B-3
Annapolis, MD 21401

FOREWORD

The Maryland Power Plant Research Program funded this project to assess the status of utility-operated power plants in Maryland in meeting nitrogen oxides (NO_x) Reasonably Available Control Technology (RACT) requirements, and to discuss new and evolving NO_x requirements that could affect power plant operations in the State.

The report was prepared by Environmental Resources Management (ERM) under the Maryland Department of Natural Resources Power Plant Research Program (PPRP) Atmospheric Sciences Integrator contract (PR95-053-001). The report was prepared under the direction of Dr. John Sherwell of PPRP. Contributing authors were: Daniel Goldstein, David Dunn, and Drew Cressman of ERM.

ABSTRACT

This report provides a discussion of the measures utilities have implemented at power plants in Maryland to meet nitrogen oxide (NO_x) Reasonably Available Control Technology (RACT) requirements. Low NO_x burners and overfire air were the technologies chosen for emissions reductions to meet RACT emission limits. A review of the effectiveness of the installed technologies since installation is provided in comparison with emission reductions from similar units operating in surrounding states. The impact of regulations recently promulgated or in development that will require additional NO_x emission reductions are discussed.

With the exception of the Potomac Electric Power Company's Chalk Point Unit 4, which was already equipped with low NO_x burners, no utility boiler in Maryland was able to comply with the presumptive NO_x RACT limits of COMAR 26.11.09. As a result, alternative emission limits were proposed by utility sources to comply with RACT. Low NO_x burners were proposed by utility sources, where economically feasible, to comply with the alternative limits. A total of nine of the 19 operating units in Maryland currently utilize low NO_x burners; the remainder have no add-on control or burner modifications to reduce NO_x emissions. It is noted that similar units (boiler type, size, and fuel combusted) operating in surrounding states with low NO_x burners have reported NO_x emissions and emissions reductions similar to those experienced by Maryland units. Additional NO_x emissions reductions will be required to meet NO_x emissions limits for utility units mandated by other air regulations. A summary of the required restrictions for Maryland utility units is provided in this report.

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1.0 INTRODUCTION

1.1 PURPOSE OF THIS REPORT

In 1993, the Maryland Power Plant Research Program (PPRP) published information on available control technologies to reduce nitrogen oxides (NO_x) emissions from power plants in two reports entitled *Background Information for RACT Determination of NO_x Emissions from Maryland Power Plants Part 1 - Boilers,* and *Part 2 - Combustion Turbines* (PPRP, 1993a and PPRP, 1993b). These reports were aimed at providing information to determine technologies that would be considered to meet Reasonably Available Control Technology (RACT) requirements for utility boilers and combustion turbines operating in Maryland. The reports identified available control technologies, associated costs, and achievable emissions reductions. Since issuance of the reports, Maryland utilities have submitted RACT proposals to the Maryland Department of the Environment (MDE) and implemented NO_x RACT compliance plans, accordingly.

The purpose of this report is to identify those measures each Maryland utility has implemented to meet RACT requirements. The purpose of this report is not to discuss in detail the available control technologies that can be utilized for NO_x emission reductions, but rather discuss those implemented by Maryland utility sources to meet NO_x RACT requirements. This report reviews how effective RACT controls or techniques have been on the implemented units based on emissions data; where available, the actual costs associated with these measures; and the advantages or disadvantages of each. In addition, the report discusses potential future NO_x requirements that will require utilities to provide additional NO_x emission reductions. An evaluation of these emissions reductions in comparison with similar boiler types operating in Maryland and around the United States in terms of NO_x emission reductions is also provided.

1.2 BACKGROUND

1.2.1 Regulatory Issues

Title I of the Clean Air Act (CAA) Amendments of 1990 requires control of NO_x and volatile organic compound (VOC) emissions to bring ozone nonattainment areas and the Northeast Ozone Transport Region (OTR) into attainment with the National Ambient Air Quality Standard (NAAQS) for ozone. The control program for existing sources is referred to as RACT. The State of Maryland State Implementation Plan (SIP) was revised in 1993 to incorporate NO_x RACT regulations for achieving the necessary NO_x emissions reductions.

Maryland's NO_x Reduction program is being implemented in three phases. The first phase required affected sources to implement RACT by 31 May 1995. The second phase includes the adoption of the NO_x Budget Rule, which requires a reduction in NO_x emissions from stationary sources by 65 percent of 1990 levels before the 2000 ozone season. In the third phase of NO_x reductions, the State of Maryland is required to reduce NO_x emissions to meet a statewide budget established by the USEPA by 2007.

Maryland’s NO_x RACT regulations are codified as Title 26, Subtitle 11, Chapter 9, Regulation 8 of the Code of Maryland Regulations (COMAR 26.11.09.08). Major stationary sources of NO_x emissions in Maryland are required to meet the NO_x RACT standards. Major NO_x sources are defined as installations at a premise that have a total potential to emit as follows:

- 25 tons or more per year of NO_x and is located in Baltimore City, or Anne Arundel, Baltimore, Carroll, Cecil, Harford, or Howard Counties;
- 50 tons or more per year of NO_x and is located in Calvert, Charles, Frederick, Montgomery, or Prince George’s Counties; or
- 100 tons or more per year of NO_x and is located in the remaining counties of the State.

Affected sources are provided the option of meeting the NO_x RACT requirements in Maryland in one of two ways:

- meet a defined emission limit defined in the regulation, known as the “presumptive RACT” standard; or
- develop a NO_x RACT proposal indicating an alternative RACT for consideration by MDE. To demonstrate the effectiveness of an alternative to the presumptive RACT emission limit, a source must conduct an evaluation of technical and economic feasibility.

Maryland’s regulations provide for the use of emissions reduction averaging - the so-called “RACT bubble” - between regulated sources under common ownership, as recommended by the United States Environmental Protection Agency (EPA). This approach can be utilized by regulated sources as an alternative RACT option. The RACT bubble can apply to sources in Maryland, or as allowed by MDE, can include sources outside of Maryland consistent with policies established by the Ozone Transport Commission (OTC) and EPA. The RACT bubble allows an owner of more than one regulated source to achieve overall NO_x emission reductions for several sources, as long as that reduction is equivalent to the NO_x emission reduction that would be achieved if each individual source complied with RACT. In this way, some sources do not have to reduce NO_x emissions provided additional reductions are experienced at other sources.

To demonstrate compliance with the presumptive RACT standards, a source was required to submit supporting information to MDE. For sources electing to utilize an alternative approach, a RACT proposal was required to be submitted for consideration. Maryland utility sources were required to submit NO_x RACT proposals by 1 July 1993 for all CAA Title IV (acid rain provisions) Phase I affected units, and by 15 February 1994 for all other affected units. All sources were to have implemented the appropriate RACT requirements by 31 May 1995.

There is no emissions or control threshold defining NO_x RACT. RACT is defined in the Maryland regulations as:

> the lowest emissions limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility (COMAR 26.11.01.01(40)).

Similarly, EPA did not provide a "bright line" definition of "economic feasibility." Maryland adopted a cost-effectiveness value of $2,000 per ton of NO_x removed as an acceptable guideline for economic feasibility. This value varies from state to state. Commonly, sources can demonstrate that retrofitting existing equipment with add-on control is not economically feasible. This is especially true for utility sources where many different types and ages of sources are operated, providing difficulty for retrofit.

In response, several organizations developed their own guidance for what constitutes RACT. One of these organizations, the State and Territorial Pollution Program Administrators / Association of Local Air Pollution Control Officials (STAPPA / ALAPCO), recommended emissions limitations of 0.38 pounds of NO_x per million British Thermal Units (lb NO_x / MMBTU) measured as a 24-hour average, for both the tangentially and dry bottom wall-fired types of boilers. Maryland regulators adopted the STAPPA / ALAPCO standard as presumptive RACT, as well as the emission limits for other types of boiler configurations noted in Table 1-1.

Table 1-1 Presumptive NO_x RACT Emission Limits for Fuel-Burning Equipment (24-hour Average)

Fuel	Tangentially-Fired (lb/MMBTU)	Wall-Fired (lb/MMBTU)	Cyclone (lb/MMBTU)
Gas only	0.20	0.20	N/A
Gas/Oil	0.25	0.25	0.43
Coal (dry bottom)	0.38	0.38	N/A
Coal (wet bottom)	1.00	1.00	0.55

Source: COMAR 26.11.09, 1995

1.2.2 Affected Units and This Report

This report focuses on the NO_x RACT plans proposed by utility sources operating in Maryland. Four investor-owned utilities with affected facilities in Maryland include: Baltimore Gas & Electric Company (BGE), Conectiv (formerly Delmarva Power and Light Company), Potomac Electric Power Company (PEPCO), and Potomac Edison Company (PE). The sources operated by these utilities include stationary electric generation units, combustion turbines, and auxiliary steam boilers. Three other utility entities operate electrical generation equipment (combustion turbines and diesel engines) in Maryland that are affected facilities under RACT: the Southern Maryland Electrical Cooperative (SMECO), the Berlin Municipal Electric Utility, and the Easton Utilities Commission. The stationary electric generation units are the largest emitters of NO_x from these utility sources.

The utility facilities in Maryland that were subject to NO_x RACT are listed in Table 1-2.

Table 1-2 Utility Sources Subject to NO_x RACT

Utility	Plant Name	Unit No.	Rated Capacity (MW)	Boiler Configuration	Primary Fuel
PEPCO[1]	Dickerson	1	191	Tangential	Coal
		2	191	Tangential	Coal
		3	191	Tangential	Coal
		CT1-CT3	349	Combustion Turbines	Oil
	Chalk Point	1	355	Dry Bottom	Coal
		2	355	Dry Bottom	Coal
		3	640	Tangential	Oil
		4	640	Tangential	Oil
		CT1-CT7	491	Combustion Turbines	Oil
		AB1-AB5	--	Auxiliary Boilers	Oil
	Morgantown	1	603	Tangential	Coal
		2	603	Tangential	Coal
		CT1-CT6	300	Combustion Turbines	Oil
		AB1-AB4	--	Auxiliary Boilers	Oil
	Station H	CT1-CT2	276	Combustion Turbines	Natural Gas
BGE[2,3,4]	Brandon Shores	1	640	Dry Bottom	Coal
		2	640	Dry Bottom	Coal
	C.P. Crane	1	190	Cyclone	Coal
		2	190	Cyclone	Coal
		CT1	14	Combustion Turbine	Oil

Table 1-2 Utility Sources Subject to NO_x RACT (continued)

Utility	Plant Name	Unit No.	Rated Capacity (MW)	Boiler Configuration	Primary Fuel
BGE[2,3,4] *(cont'd)*	Wagner	1	137	Dry Bottom	Oil
		2	134	Dry Bottom	Coal
		3	319	Cell Burner	Coal
		4	398	Dry Bottom	Oil
	Gould Street	3	104	Dry Bottom	Oil
	Riverside	4	78	Dry Bottom	Gas
		CT6-CT8	172	Combustion Turbines	2-Oil and 1-Gas
	Westport	3	100	Wall Fired	Oil
		4	120	Wall Fired	Oil
		CT5	132	Combustion Turbine	Natural Gas
	Notch Cliff	CT1-CT8	128	Combustion Turbines	Natural Gas
	Perryman	CT1-CT6	368	Combustion Turbines	4-Diesel and 2-Oil
	Philadelphia Road	CT1-CT4	64	Combustion Turbines	Diesel
Conectiv[4,5]	Vienna	8	155	Tangential	Oil
		CT1	1	Combustion Turbine	Oil
	Crisfield	CT1-CT4	10	Stationary Combustion Engines	Diesel
PE[4,6]	R.P. Smith	9	33	Dry Bottom	Oil
		11	81	Tangential	Oil

Table 1-2 Utility Sources Subject to NO_x RACT (continued)

Utility	Plant Name	Unit No.	Rated Capacity (MW)	Boiler Configuration	Primary Fuel
Southern Maryland Electrical Cooperative (SMECO)[4]	Chalk Point	CT1	84	Combustion Turbine	Natural Gas
Berlin Municipal Electric Utility[4]	Berlin	E1-E5	5	Stationary Combustion Engines	Diesel
Easton Utilities Commission[4]	Easton	E1-E16	57	Stationary Combustion Engines	Diesel

Sources: [1] PEPCO, 1993.
[2] BGE, 1993 and BGE, 1994
[3] PPRP, 1993a and PPRP, 1993b
[4] PPRP, 1996
[5] Delmarva Power and Light, 1993
[6] Potomac Edison, 1994

Technologies utilized as RACT to reduce NO_x emissions were implemented on the larger NO_x emitting units and included primarily low NO_x burners and overfire air. Because RACT incorporates cost-effectiveness as a measure for applicability, only the larger electric power generating units operated by BGE, PEPCO, PE and Conectiv were determined to require low NO_x burners or overfire air to reduce NO_x emissions. No additional requirements beyond combustion optimization were determined by the other units' owners / operators to meet NO_x RACT requirements.

The NO_x RACT proposals submitted by the following utilities for the noted facilities are discussed in detail in this report:

- PEPCO's Dickerson Station, Chalk Point Station, and Morgantown Station;
- BGE's Brandon Shores, C. P. Crane, and H. A. Wagner plants;
- Conectiv's Vienna facility; and

- PE's R.P. Smith facility.

Available continuous emissions monitoring system (CEMS) data reported by each facility on a quarterly basis to the EPA was used to evaluate NO_x emissions reductions since 1995, after the NO_x RACT technologies were implemented. CEMS data were obtained from EPA's emissions tracking system (ETS) Acid Rain Web Site on the Internet (at the time of printing http://www.epa.gov/acidrain/ets/etsrpts.html).

In most cases, retrofit NO_x control technology is not cost effective for combustion turbines or stationary diesel-fired combustion engines. The utility sources therefore, recommended combustion optimization for these units. CEMS for measuring NO_x emissions have not generally been required on combustion turbines and stationary diesel-fired combustion units; therefore, emissions calculated using the EPA emissions factors from AP-42 *Compilation of Air Pollutant Emission Factors* (EPA, 1995) are available for these units. Because no retrofit NO_x technology has been implemented as RACT, and because only AP-42 data is available, combustion turbines, auxiliary boilers, and stationary diesel-fired combustion engines noted in Table 1-2 are not discussed further in this report.

2.0 NO_x RACT TECHNOLOGIES IMPLEMENTED BY MARYLAND UTILITIES

NO_x RACT proposals were submitted to MDE by Maryland utilities to meet the July 1993 and February 1994 submission deadlines. This section summarizes the information presented in these proposals and describes the NO_x RACT technology implemented or proposed to be implemented by each Maryland utility.

2.1 PEPCO

PEPCO's NO_x RACT proposal (PEPCO, 1993) submitted to MDE in July 1993 addresses the company's Title IV Phase I affected units, Chalk Point and Morgantown, as well as its other steam electric units, including the Dickerson plant in Maryland and others in Virginia and the District of Columbia. PEPCO indicated interest in pursuing the compliance strategy endorsed by the EPA wherein units are allowed to trade among themselves in order to satisfy their aggregate NO_x RACT reduction requirements. The emission reduction averaging (or "RACT bubble") approach is allowed as an alternative method to achieve NO_x RACT compliance under COMAR 26.11.09.08D.

The Chalk Point facility consists of two dry bottom coal-fired steam generators (Units 1 and 2) each rated at 355 MW, and two tangentially-fired fuel oil steam generators (Units 3 and 4) at 640 MW each. The Morgantown Station consists of two tangentially fired coal burners, Units 1 and 2, each with a rated capacity of 603 MW. The Dickerson Station operates three tangentially coal-fired steam electric generators (Units 1, 2, and 3) with a capacity of 191 MW each.

2.1.1 Presumptive RACT Limits

Of these nine steam electric generating units subject to NO_x RACT, PEPCO indicated that only Units 3 and 4 at Chalk Point could satisfy Maryland's presumptive NO_x emissions limits of 0.25 lb / MMBTU (24-hour average). PEPCO agreed to achieve this NO_x emission limit for Units 3 and 4 by 31 May 1995.

2.1.2 Alternative RACT

According to the NO_x RACT evaluation conducted by PEPCO, none of the remaining boilers (a total of seven coal-fired units at Dickerson (three units), Chalk Point (two units), and Morgantown (two units)), can reasonably achieve the NO_x emission limit of 0.38 lb / MMBTU (presumptive RACT for coal-fired dry bottom units). In its RACT proposal, PEPCO provided a detailed justification to demonstrate that separated overfire air (SOFA) cannot reasonably be considered NO_x RACT for these seven coal-fired utility boilers. PEPCO explains that while SOFA has been demonstrated on several new coal-fired units (where its performance requirements have been integrated into the initial design and construction of such units), the application of SOFA as a retrofit technology is still premature. PEPCO states:

> SOFA does have significant potential for retrofit applications, but much more information needs to be developed through demonstrations of the installation and operation of such a technology at a variety of current coal-fired facilities. Inasmuch as RACT is not intended to be a technology-forcing requirement, SOFA cannot be considered RACT for the Company's seven coal-fired units in Maryland (PEPCO, 1993).

PEPCO does, however, show that low NO_x burners have been retrofitted in coal-fired units and are more appropriate for RACT in the situations at these plants. On the basis of this argument of technical feasibility, PEPCO concluded that low NO_x burners represent NO_x RACT for those seven units.

To demonstrate that the NO_x reductions expected with application of low NO_x burners are achievable, PEPCO conducted NO_x emission testing to define uncontrolled levels of NO_x from each unit. Emissions were measured at each boiler type and fuel type operated by PEPCO. To develop a correlation between NO_x emission rate (lb / MMBTU) and varying unit loads or operating rates, PEPCO measured NO_x emissions at a minimum of three load levels (i.e., at low, medium and full conditions). By developing this NO_x -load profile for each boiler and fuel type, PEPCO determined the average annual uncontrolled NO_x emission rates for each unit. Table 2-1 summarizes the NO_x emission rates for each PEPCO unit calculated from the testing data.

Table 2-1 Uncontrolled NO_x Emission Rates for PEPCO Units (lb/MMBTU)

Steam Generating Unit	Short-term or Maximum Emission Rate (lb/MMBTU)	Load-weighted Average Annual Emission Rate* (lb/MMBTU)
Dickerson Unit 1	0.78	0.65
Dickerson Unit 2	0.78	0.70
Dickerson Unit 3	0.76	0.70
Chalk Point Unit 1	1.35	1.24
Chalk Point Unit 2	1.35	1.23
Chalk Point Unit 3	0.32	0.28
Chalk Point Unit 4	0.30	0.29
Morgantown Unit 1	1.02	0.95
Morgantown Unit 2	1.02	0.95

*The load-weighted annual NO_x emission rate was calculated by multiplying the NO_x emission rate at a given load by the fraction of annual operating time that the unit operated at the given load.

Source: PEPCO, 1993.

PEPCO completed an "extensive analysis" of the predicted performance of low NO_x burner retrofits and concluded that the presumptive limit of 0.38 lb/MMBTU could not be achieved at any of the facilities to which it applies. Instead of the presumptive limit, PEPCO requested alternative NO_x RACT limits to be achieved with the installation of low NO_x burners on each unit, as shown in Table 2-2.

Table 2-2 PEPCO's Alternative NO_x RACT Limits

Steam Generating Unit	Boiler Type	Alternative NO_x RACT Emission Limit (lb/MMBTU)*
Dickerson Unit 1	Tangentially Fired	0.53
Dickerson Unit 2	Tangentially Fired	0.53
Dickerson Unit 3	Tangentially Fired	0.53
Chalk Point Unit 1	Dry Bottom Wall Fired	0.70
Chalk Point Unit 2	Dry Bottom Wall Fired	0.70
Morgantown Unit 1	Tangentially Fired	0.95
Morgantown Unit 2	Tangentially Fired	0.95

*24-hour average

Source: PEPCO, 1993.

The boilers at Dickerson, Chalk Point, and Morgantown were installed in the 1960s when boilers were constructed with smaller furnace sizes that maintained high heat release rates. These design types, with high furnace temperatures within constrained furnace volumes, maximize the potential amount of combustion, but are conducive to the formation of NO_x. Therefore, the NO_x emission rate achievable by a particular combustion modification is a function of the existing furnace design. PEPCO used this argument to say that alternative RACT limits are "not only appropriate but necessary" (PEPCO, 1993).

PEPCO prepared estimates of the capital and operating costs required to meet the proposed alternative RACT limits with low NO_x burners at each of its facilities. The estimated total capital cost for all 16 of PEPCO's units was $373 million. Table 2-3 summarizes the projected costs for the PEPCO units located in Maryland.

Table 2-3 PEPCO NO_x Control Costs for Maryland Units[1]

Steam Generating Unit (With low NO_x burners except as noted)	Estimated Average NO_x Emissions (ton/yr)	NO_x Removed (ton/yr)	Max. Antici-pated % NO_x Reduc.	1992 Total Plant Capital Cost ($MM)	1992 First Yr. O&M Cost ($ M)	Retrofit Cost ($/kW)	Cost Effective-ness ($/ton removed)
Dickerson Unit 1[2]	4,102	1,044-1,859	45%	36.5	53-57	187-192	3,155-5,460
Dickerson Unit 2[2]	4,295	1,091-1,945	45%	36.5	52-56	187-192	3,014-3,562
Dickerson Unit 3[2]	4,310	1,089-1,948	45%	36.5	52-56	187-192	3,010-5,233
Chalk Point Unit 1	12,877	6,200	48%	34.5	496	97	1,014
Chalk Point Unit 1[3]	12,877	8,108	63%	35.0	516	99	789
Chalk Point Unit 2	12,685	6,108	48%	34.5	496	97	1,029
Chalk Point Unit 2[3]	12,685	7,987	63%	35.0	516	99	801
Chalk Point Unit 3[4]	4,290	970	23%	11.9	156	19	2,216
Chalk Point Unit 4[4]	3,251	542	17%	11.9	156	19	3,966
Morgantown Unit 1[2]	16,725	1,019-5,820	35%	42.0	189-203	69-70	1,213-6,753
Morgantown Unit 2[2]	16,669	1,015-5,796	35%	42.0	189-202	69-70	1,218-6,779

(1) All costs in 1992 Dollars. Estimated emissions based on 1992 stack test data.
(2) The ranges shown for Dickerson and Morgantown represent three low NO_x concentric firing system scenarios that were evaluated.
(3) Low NO_x burners with Overfire Air
(4) The figures for Chalk Point Units 3 and 4 are for reductions to meet the applicable RACT limit of 0.25 lb / MMBTU.
$MM indicates million dollars
$M indicates thousand dollars
Source: PEPCO, 1993

PEPCO's analysis of this cost data questions whether low NO_x burners at Dickerson and Morgantown should even be considered RACT. Annual costs per ton of NO_x removed of $5,000-6,000 per ton do not appear to be economically feasible, given MDE's cost effectiveness criteria of $2,000 per ton removed. Because of cost effectiveness arguments, PEPCO does not accept low NO_x burners as RACT for the coal-fired units at Dickerson and Morgantown; PEPCO believes that the units currently meet RACT.

PEPCO recognized that further NO_x reductions may be required in the future, and therefore included cost estimates for control technologies that may be required to achieve additional NO_x emission reductions beyond RACT. One of these estimates, low NO_x burners combined with SOFA (included in Table 2-3) shows that the SOFA / low NO_x burner combination provides an additional 15% NO_x reduction over low NO_x burners alone. PEPCO explains that the cost estimates for these “beyond RACT” controls are incomplete and inaccurate. For example, the cost-effectiveness of the retrofit SOFA as shown appears to be lower than that of retrofit low NO_x burners on the Chalk Point units. This finding is the result of the unavailability of reliable data, such as actual costs to operate SOFA.

2.1.3 Implementation of NO_x RACT at PEPCO Facilities

Units 1 and 2 at Chalk Point are retrofitted with Riley Stoker low NO_x burners with overfire air. The Unit 1 burner was installed in 1995 and Unit 2 in 1994. PEPCO applied for an alternate emission limit (AEL) for Unit 1 in 1995 and planned to apply for an AEL for Unit 2 in 1997. Unit 3 at Chalk Point, which burns oil and gas, has capability for overfire air, but generally does not operate with overfire air. Unit 4 is subject to New Source Performance Standards (NSPS), so is equipped with a low NO_x burner operating with limited overfire air.

Units 1 and 2 at Morgantown are equipped with low NO_x burners. The boilers and burners are both Combustion Engineering units that operate with a "sophisticated neural network" control system that allows the operator to select a specific NO_x emission based on operating efficiency.

None of the units at Dickerson currently operates with a specific RACT control technology to limit NO_x emissions.

2.2 BGE

In July 1993, BGE submitted a NO_x RACT proposal (BGE, 1993) for its CAA Title IV, Phase I affected units at the C.P. Crane Station (Units 1 and 2). Both units are cyclone coal-fired boilers rated at 190 MW. As BGE explains in its RACT proposal, there are currently no economical, commercially demonstrated combustion modification techniques that exist to reduce NO_x emissions from cyclone boilers. Low NO_x burner technology is not applicable due to boiler configuration and operations. Overfire air is not applicable because staging will significantly alter the heat release profile, which changes the slagging rates and properties. Operational adjustments, such as low excess air or modifications to include overfire air, cannot be considered due to minimum furnace design requirements. Reburning technology is the only known combustion control for cyclone boilers; however, both gas and coal reburning were in the developmental stage when RACT was proposed; BGE maintained that long-term testing is required to address control performance, operational impacts, and commercial feasibility adequately (BGE, 1993). BGE has determined that post-combustion controls such as catalytic and selective non-catalytic reduction are priced beyond the RACT criteria.

MDE's response in a January 1996 letter (MDE, 1996) to BGE's NO_x RACT proposal for C.P. Crane indicated that BGE must reconsider NO_x RACT to be consistent with what other similar sources in the OTR have implemented. A meeting between MDE and BGE was held on 26 March 1997 (BGE, 1997a) which resulted in a commitment by BGE to retrofit Unit 1 at C.P. Crane with gas reburner technology to affect NO_x emissions reductions. However, according to BGE personnel, this technology is not being implemented to meet RACT, but rather to meet future NO_x emission reduction requirements, which we discuss further in Section 4 of this report.

BGE's February 1994 NO_x RACT proposal (BGE, 1994) addressed the remainder of its system, including the following sites:

- Brandon Shores' two dry bottom (wall) coal-fired boilers (Units 1 and 2), each rated at 640 MW;
- Wagner's fuel oil-fired dry bottom boiler (Unit 1) rated at 137 MW, one coal-fired dry bottom boiler (Unit 2) rated at 134 MW, one coal-fired cell burner (Unit 3) rated at 319 MW, and one fuel oil-fired dry bottom boiler (Unit 4) rated at 398 MW;
- Riverside's gas-fired dry bottom boiler (Unit 4) rated at 78 MW; and
- Gould Street's dual (gas and oil) fired boiler (Unit 3) rated at 100 MW.

In its RACT proposal, BGE points out that Units 1 and 2 at Brandon Shores were originally installed with low NO_x burners, and low NO_x burners are proposed for Wagner Unit 2. In a January 14, 1996 letter from MDE (MDE, 1996) to BGE, MDE indicated that it considered low NO_x burners as NO_x RACT for these units after consultation with other state regulatory agencies. MDE incorporated low NO_x burner requirements into each facility's operating permit accordingly.

No additional RACT was proposed by BGE for the remaining equipment covered in the proposal. In the case of Wagner Unit 3, no applicable technology exists for a three-cell burner. For the remaining boilers, Wagner Units 1 and 4, and Riverside Unit 4, BGE concluded that the limited NO_x control options are not economically reasonable. The estimated costs associated with additional NO_x reduction controls by BGE are summarized in Table 2-4.

Table 2-4 NO_x Reduction Control Costs

Generating Unit	Technology Evaluated	Capital Cost ($MM)*	Annual Operating Cost ($MM)*	Cost/Ton NO_x Removed ($)
C.P. Crane Unit 1	Gas Reburn	30	12	5,000
C.P. Crane Unit 2	Gas Reburn	30	12	5,000
Brandon Shores Unit 1	OFA	6-12	2.5-3	Not Determined
Brandon Shores Unit 2	OFA	6-12	2.5-3	Not Determined
Wagner Unit 1	LNB/OFA	4-15	Not Determined	2MM-19MM
Wagner Unit 2	NA	NA	NA	NA
Wagner Unit 3	NA	NA	NA	NA
Wagner Unit 4	LNB/OFA	4-15	Not Determined	2MM-19MM
Riverside Unit 4	LNB/OFA	4-15	Not Determined	2MM-19MM
Gould Street	LNB/OFA	4-15	Not Determined	2MM-19MM

LNB indicates a low NO_x burner
OFA indicates overfire air
* Costs are in 1992 dollars
"Not Determined" indicates that this information was not provided in BGE's NO_x RACT proposal.

Source: BGE, 1993 and BGE, 1994.

BGE reached a similar conclusion for its combustion turbines. Although new combustion turbine units can be equipped with NO_x limiting combustors, NO_x emission control for existing combustion turbines is generally limited to water or steam injection, which are not likely reasonable on a cost effectiveness basis.

In addition to combustion controls at Brandon Shores and Wagner Unit 2, BGE proposed seasonal fuel switching at Wagner Unit 1 and Riverside Unit 4. Six generating units were also removed from service between 1990 and 1994, resulting in a 3,000-ton reduction in NO_x emissions from the 1990 baseline year.

2.2.1 *Alternative RACT*

BGE provided actual (uncontrolled) NO_x emission rates for each unit. These peak and annual average emission rates were based on 1992 emission data for Crane and Brandon Shores. For Wagner, Riverside, and Gould Street, emission rates represent estimated annual average NO_x emissions (see Table 2-5).

None of the ten BGE units subject to Maryland NO_x emission limits was able to satisfy Maryland's presumptive NO_x RACT emissions limits; however, BGE did not specify proposed alternate RACT emission limits in its proposals. Alternative NO_x RACT emission limits were established by MDE for the BGE units and have been incorporated into their respective state operating permits. These limits are provided in Table 2-6.

Table 2-5 Uncontrolled NO_x Emission Rates for BGE Units

Unit	Peak NO_x Emissions (lb/MMBTU)	Annual Average NO_x Emissions (lb/MMBTU)
C.P. Crane Unit 1	1.30	1.20
C.P. Crane Unit 2	1.40	1.34
Brandon Shores Unit 1	0.50	0.42
Brandon Shores Unit 2	0.55	0.48
Wagner Unit 1	0.31	0.10*
Wagner Unit 2	0.85	0.82*
Wagner Unit 3	1.18	1.18*
Wagner Unit 4	0.55	0.55*
Riverside Unit 4	0.30	0.30*
Gould Street Unit 3	0.30	0.30*

*Estimated annual average NO_x emission rates; no actual data reported by BGE.

Source: BGE, 1994.

2.2.2 *Implementation of NO_x RACT at BGE Facilities*

BGE stated in its NO_x RACT plan that RACT was satisfied by current operation, and that no add-on controls or retrofits were required to meet

RACT for any units except Brandon Shores Units 1 and 2, and Wagner Unit 2. Both Brandon Shores units already were operating with low NO_x burners at the time the RACT proposals were submitted, so no change was required. Wagner Unit 2 was proposed to be retrofitted with low NO_x burners, which was completed in the first quarter of 1995.

2.3 CONECTIV

Conectiv outlined its NO_x RACT proposal in a letter to MDE dated 15 November 1993 (Delmarva Power and Light, 1993). Included in this submission was information on the company's Maryland facilities: the Vienna Power Plant and the Crisfield Peaking Facility. The Vienna facility consists of Unit 8 (tangential-fired, oil fueled boiler rated at 155 MW) and an oil-fired combustion turbine rated at 1 MW. The Crisfield facility consists of Units 1 through 4 (two-stroke cycle turbo-diesel engines) each rated at 2.5 MW.

Conectiv indicated that the Vienna Unit 8 was not able to meet the Maryland presumptive NO_x RACT limits and proposed alternatively to continue to operate the unit by optimizing combustion efficiency. As part of this alternative RACT proposal, Conectiv planned to implement a program for operating personnel which focuses on activities that will optimize existing combustion system operations to minimize NO_x emissions. No specific NO_x emissions limits were proposed.

Retrofit NO_x emissions reduction technology for the combustion turbines operated at the Crisfield facility were found by Conectiv to be economically infeasible as RACT.

2.4 POTOMAC EDISON

Potomac Edison submitted a NO_x RACT proposal for the R. P. Smith Power Station in February 1994 (PE, 1994). R.P. Smith consists of two boilers with a total capacity of 114 MW. Boiler Number 11 (also referred to as Unit No. 4) is a tangentially-fired, coal-burning, dry-bottom unit. Boiler Number 9 (also referred to as Unit No. 3) is a wall-fired, coal-burning, dry-bottom unit.

Potomac Edison proposed compliance with Maryland's NO_x RACT regulation by:

- the installation of a low NO_x Concentric Firing System - Level III (LNCFS-III) on Boiler Number 11 to meet a 0.45 lb NO_x / MMBTU limit on a 30-day rolling average;

- evaluating and developing recommendations to optimize Boiler Number 9 for NO_x boiler emissions reductions; and
- collecting NO_x CEM data for Boiler Number 9 until 31 August 1994 to determine a baseline value.

Testing conducted prior to installation of CEMs equipment and NO_x control resulted in the following baseline NO_x emissions: Boiler Number 11 ranged from 0.65 lb / MMBTU to 0.78 lb / MMBTU and Boiler Number 9 ranged from 0.67 lb / MMBTU to 0.85 lb / MMBTU.

While PE determined NO_x RACT to be low NO_x burners (specifically, LNCFS-III) for Boiler Number 11, low NO_x burners were not believed to be RACT for Boiler Number 9 because of the high cost of installation of low NO_x burners on that unit.

PE projected a cost per ton removed for the low NO_x burners on Boiler Number 11 of $1,308 / ton, with emissions of 0.45 lb NO_x / MMBTU, a projected NO_x removal of 49%. Installation of low NO_x burners on boiler Number 9 was projected to cost $12,438 / ton of NO_x removed, due to considerable combustion control modifications and boiler waterwall improvements that would be necessary, to provide a NO_x removal of 50%.

Thus, as NO_x RACT, PE recommended a low NO_x system with emissions of 0.45 lb NO_x / MMBTU for Boiler Number 11, and no retrofit with emissions of 0.85 lb NO_x / MMBTU for Boiler Number 9. A summary of the NO_x emissions limits for each R.P. Smith unit as a condition of the plant's operating permit (MDE, 1996) is provided in Table 2-6.

Table 2-6 NO_x RACT Operating Permit Conditions for Maryland Utilities

Station	Unit No.	MDE State Operating Permit No.	NO_x RACT Limit (lb NO_x/MMBTU)	NO_x Control
PE				
R.P. Smith	9	21-00005	0.83	NA
R.P. Smith	11	21-00005	0.63	LNB w / SOFA
BGE				
Brandon Shores	1	02-00468	0.55	LNB
Brandon Shores	2	02-00468	0.63	LNB
Gould Street	3	24-00007	0.39	NA
Wagner	1	02-00014	0.49	NA
Wagner	2	02-00014	0.70	LNB
Wagner	3	02-00014	1.46	NA
Wagner	4	02-00014	0.68	NA
Riverside	4	03-00078	0.36	NA
Conectiv				
Vienna	8	*	*	*

All NO_x RACT limits are on a 30-day rolling average basis.
NA indicates no NO_x control required beyond good combustion operation.
PEPCO has implemented a state-wide emissions averaging approach for its units, and so PEPCO units are not included here.

Source: Operating Permits issued by MDE for each plant.
*Not available at time of printing.

2.5 *SUMMARY OF APPROVED NO_x RACT*

The review and approval process in Maryland for utility NO_X RACT sources basically has been conducted in accordance with the following process:

- Regulated sources submitted information to support presumptive NO_X RACT or a proposal for an alternative NO_X RACT to MDE by July 1993 (if a regulated CAA Title IV unit) or by February 1994 for all other sources;

- Sources were required to comply with the presumptive RACT or proposed alternative NO_x RACT by 31 May 1995;
- MDE consulted with other state agencies to evaluate proposed NO_x RACT for consistency among sources, specifically those sources in the OTR;
- MDE met with regulated sources to discuss RACT proposals and reach a consensus on what defines NO_x RACT for a particular source;
- MDE incorporated the NO_x RACT requirements as a condition of the source's air operating permit; and
- MDE submitted the NO_x RACT proposal to EPA for review and incorporation into the Maryland SIP.

MDE has issued state operating permits for the power plants operating in Maryland. The Department has included NO_x RACT emission limits in these operating permits as applicable requirements. Table 2-6 summarizes the NO_x RACT requirements for those units that have been issued operating permits to date. MDE is still awaiting word from EPA on the approval of the NO_x RACT proposals for incorporation into the Maryland SIP.

The operating permit for BGE's C.P. Crane plant is still under preparation by MDE. However, MDE has provided approval to BGE to retrofit Unit 1 with gas reburn technology. Depending on the performance on Unit 1, Unit 2 will be retrofitted at a later date. Preliminary evaluations have indicated that gas reburn could reduce baseline (1990 emission levels) NO_x emissions by up to 65%. MDE has indicated that gas reburn would constitute NO_x RACT for the units, because no other currently available NO_x control technologies have been feasibly demonstrated on cyclone boilers of this size.

Based on operating permits issued to date by MDE, PEPCO has implemented a state-wide emissions averaging approach to meet NO_x RACT. This approach (alternative emissions limit allowed by Maryland NO_x RACT regulations) has been accepted by MDE (MDE, 1997) because overfire air was implemented at Chalk Point Units 3 and 4, providing additional NO_x reductions. MDE has indicated that overfire air operation on these units essentially provides a "beyond RACT" NO_x emission level. In addition, PEPCO is using an alternative emission limit on Units 1 and 2 at Chalk Point to meet NO_x RACT. These two units have been operating at an average emission rate of 0.70 lb NO_x / MMBTU heat input over the past year.

3.0 EFFECTIVENESS OF IMPLEMENTED TECHNOLOGIES

This section examines the NO_x control equipment that has been installed by Maryland utilities on steam generating units to meet RACT requirements. The effectiveness (amount of NO_x reduction) was evaluated using emissions data available from existing sources or from CEMS data. Post-RACT NO_x emission levels are compared to the reductions that utilities expected to achieve, and with NO_x reductions experienced by similar units operating elsewhere in the United States.

3.1 EMISSIONS DATA

The CAA acid rain program regulations require affected units to operate CEMS, and to submit quarterly monitoring reports (40 CFR 75.50-75.52). At the time of preparation of this report, ETS reports were available for affected units in Maryland for the first three quarters of 1996, the third quarter of 1995, and the annual summary of 1995. For the purposes of this analysis, applicable data from the ETS reports includes total (quarterly) heat input (MMBTU) and the average hourly NO_x emission rate, reported as lb/MMBTU. CEMS data from 19 units operating in Maryland, as shown in Table 3-1, were obtained through the EPA Acid Rain Division.

The CEMS data provided information on NO_x emissions after the NO_x controls were installed; however, there is no available CEMS data for the time period before control equipment was added. Therefore, to evaluate the effectiveness of NO_x RACT (i.e., compare post-RACT emissions with pre-RACT emissions), emissions data prior to control were obtained from alternative sources.

The EIA-767 (the Energy Information Administration's Steam-Electric Plant Operation and Design Report) database and additional data from the EPA Acid Rain Division provided estimates of pre-control emissions. The emissions found in both of these sources were ultimately derived from the EPA's AP-42 emission factors. These data sources provided emissions estimates for years 1990 and 1995, which in most cases was prior to installation of NO_x control.

Table 3-1 Maryland Emission Units Reporting CEMS Data

	Unit Name	Unit/Stack	Boiler Type	Primary Fuel	NO_x Controls
BGE					
	Brandon Shores	1	Dry Bottom	Coal	LNB
	Brandon Shores	2	Dry Bottom	Coal	LNB w/ SOFA
	C.P. Crane	1	Cyclone	Coal	Uncontrolled
	C.P. Crane	2	Cyclone	Coal	Uncontrolled
	Gould Street	3	Dry Bottom	Oil	Uncontrolled
	Herbert A Wagner	1	Dry Bottom	Oil	Uncontrolled
	Herbert A Wagner	2	Dry Bottom	Coal	LNB
	Herbert A Wagner	3	Cell Burner	Coal	Uncontrolled
	Herbert A Wagner	4	Dry Bottom	Oil	Uncontrolled
	Riverside	4	Dry Bottom	Gas	Uncontrolled
PEPCO					
	Chalk Point	CSE12	Dry Bottom	Coal	LNBO
	Chalk Point	3	Tangential	Oil	Uncontrolled
	Chalk Point	4	Tangential	Oil	LNB
	Dickerson	CSE123	Tangential	Coal	Uncontrolled
	Morgantown	1	Tangential	Coal	LNB
	Morgantown	2	Tangential	Coal	LNB
Conectiv					
	Vienna	8	Tangential	Oil	Uncontrolled
PE					
	R.P. Smith	9	Dry Bottom	Coal	Uncontrolled
	R.P. Smith	11	Tangential	Coal	LNB/SOFA

CSE12 - Combined Stack Emissions from Units 1 and 2
CSE123 - Combined Stack Emissions from Units 1, 2, and 3
LNB - Low NO_x Burners
LNBO - Low NO_x Burners with Overfire Air
SOFA - Separated Overfire Air

3.2 *COMPARISON OF NO_x DATA: PRE- AND POST-RACT*

The eight units (noted in Table 3-1) in Maryland with NO_x control (all low NO_x burners) have been grouped by unit type for evaluation as follows:

- Opposed, or wall, coal-fired: Chalk Point Units 1 and 2, and Brandon Shores Units 1 and 2;
- Tangentially coal-fired: Morgantown Units 1 and 2, and R.P. Smith Unit 11; and
- Tangentially oil-fired: Chalk Point Unit 4.

Figures 3-1 through 3-4 summarize the collected NO_x emissions information. In these figures, "1990 annual" represents the actual estimated emissions for that year. The 1990 value was calculated from the fuel used in that year and emission factors from AP-42. In several cases, more than one fuel type was used (i.e., oil used as a start-up fuel in a coal-fired boiler). Note that the emissions from Chalk Point Units 1 and 2 vent through a common stack. As such, the NO_x emissions from Chalk Point Units 1 and 2 are presented as combined emissions from an "effective single unit." The term "1995 annual" represents the actual emissions for that year based on CEMS data. The other data points represent the actual reported NO_x emissions recorded by CEMS for the quarter shown and was provided as another data point for assessment of the efficiency of NO_x RACT on applicable units. The "AP-42 baseline" value is provided for reference and was calculated from the maximum heat input for each unit and the applicable emission factor from EPA's AP-42 document (EPA, 1995). This baseline emission rate represents theoretical NO_x emissions from the unit without reductions from NO_x control.

Figure 3-1 NO_x Emissions for Units with Low NO_x Burners

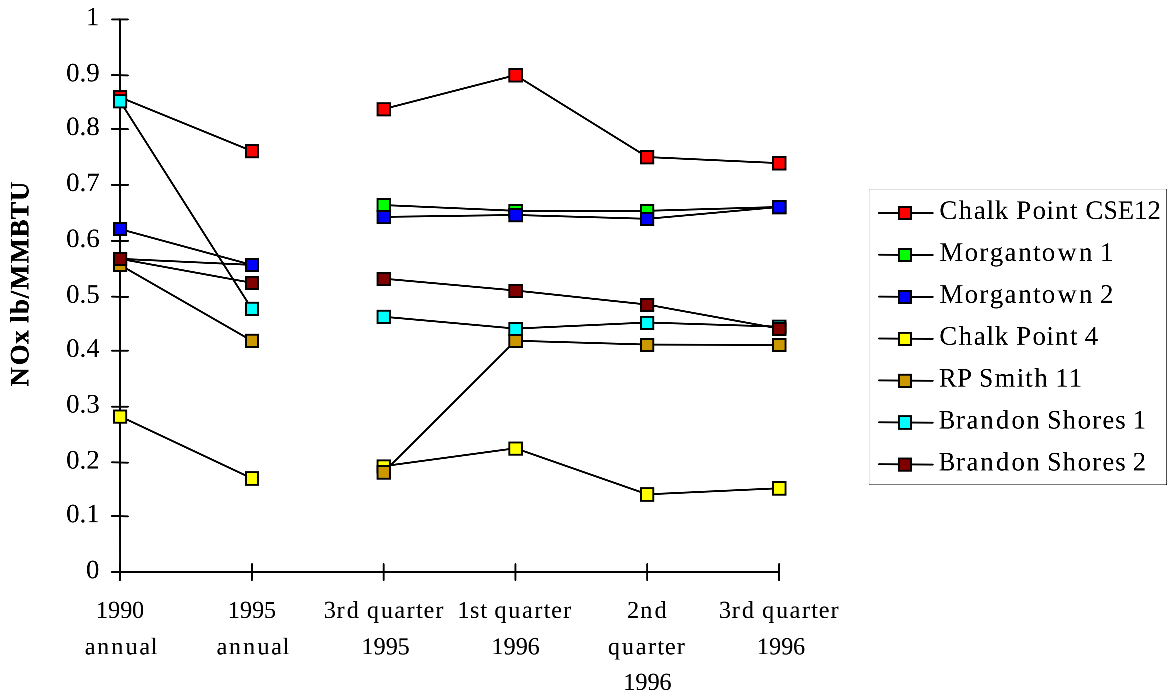
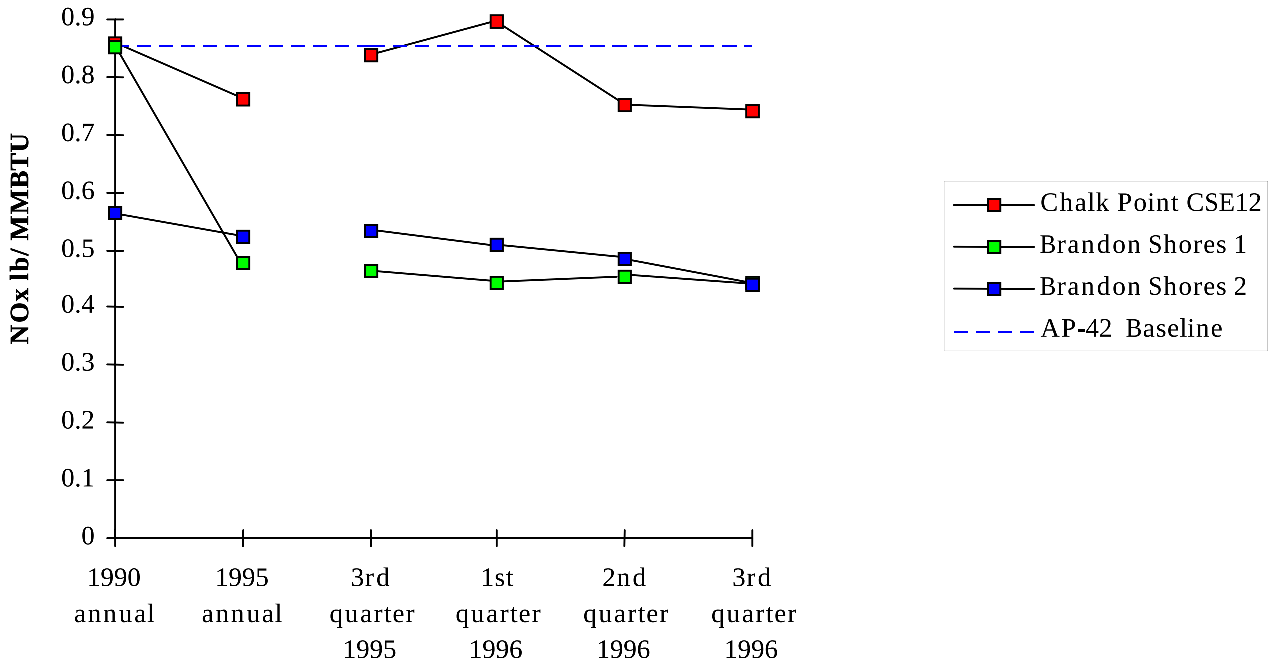


Figure 3-1 provides a general overview of the emission rates of units with low NO_x burners. A further analysis of NO_x emissions by burner type for each unit design provides insight into emission trends.

Figure 3-2 presents the emission rates of opposed (wall) coal-fired units with low NO_x burners (solid lines) in relation to the "AP-42 baseline" estimated NO_x emission rate for opposed coal-fired units without low NO_x burners. While the 1990 value and the baseline are both calculated from AP-42, they may vary slightly. The variation is due to the fact that the 1990 emissions value sometimes takes into account multiple fuels burned, whereas the baseline is determined from only the primary fuel type for that boiler.

Figure 3-2   Opposed-fired Low NO_x Burners



Based on the reported average of the quarterly CEMS data, NO_x emissions have decreased by 7% at Chalk Point, 47% at Brandon Shores Unit 1, and 12% at Brandon Shores Unit 2, compared to the 1990 emission baseline based on the AP-42 emission factor. It should be noted that Unit 2 at Brandon Shores only operated one month in 1990 (and burned more oil than coal), so the 1990 emissions do not provide an accurate comparison. When post-control emissions at this unit are compared with the baseline (an emission rate based solely on burning coal), emissions decreased by an average of 42%. This emission decrease at Unit 2 at Brandon Shores is comparable to that noted for Unit 1 over the same time period.

As previously mentioned, Chalk Point Units 1 and 2 vent through a common stack and the CEMS data is for the combined exhaust. The combined emission rate can be evaluated as an average of emissions from the two units. However, to further understand the individual NO_x emissions from each unit at Chalk Point, personnel at PEPCO were contacted.

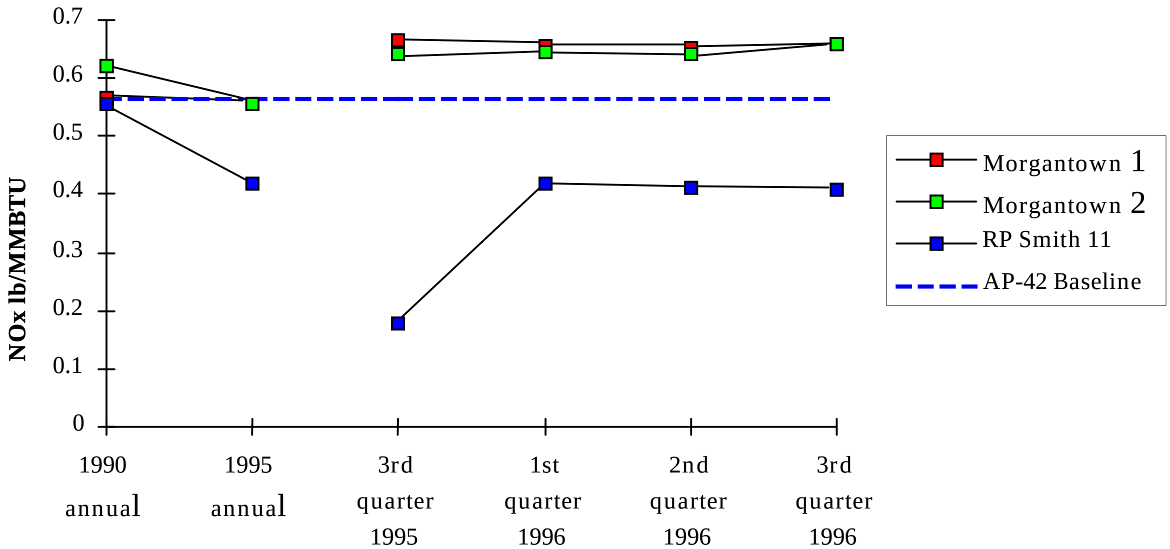
According to a PEPCO representative (PEPCO, 1997), the NO_x emission rates for Units 1 and 2 at Chalk Point before NO_x control were about 1.35

lb / MMBTU each, much higher than the AP-42 baseline value for wall-fired units of 0.86 lb / MMBTU. Low NO_x burners installed on each unit were originally guaranteed for 0.5 lb / MMBTU by the manufacturer. PEPCO is pursuing an alternate emissions limit for the units. They have installed a NO_x CEMS on the exhaust stack prior to the combined stack to provide separate unit data. According to PEPCO, Unit 1 is currently operating at an effective NO_x emission rate of 0.7 lb / MMBTU. Unit 2 is currently operating at about 1.0 lb / MMBTU. These burners have a lifetime expectancy of approximately three years; however, they have deteriorated on the Chalk Point units more quickly than expected. There have been operational problems causing the units to run at an oxygen level of about 4%, resulting in higher NO_x formation. Unit 1 is operating at a lower NO_x emission rate because it is operated at a lower oxygen content and has incurred less deterioration on the burner. The unexpected deterioration rates on Chalk Point Units 1 and 2 help to explain the minimal reductions provided by the low NO_x burners.

Units 1 and 2 at Brandon Shores are consistently operating below the calculated baseline at an average of approximately 0.5 lb NO_x / MMBTU, or 44% below the baseline levels.

Figure 3-3 presents the emissions for the tangentially coal-fired units operating with low NO_x burners. The AP-42 baseline NO_x emission rate factor for uncontrolled (without low NO_x burners) tangentially-fired boilers is about 33% lower than the rate for wall-fired units. Based on boiler design, tangentially-fired boilers generally have lower emissions than wall-fired units.

Figure 3-3 Tangentially-Fired Low NO_x Burners (Coal)

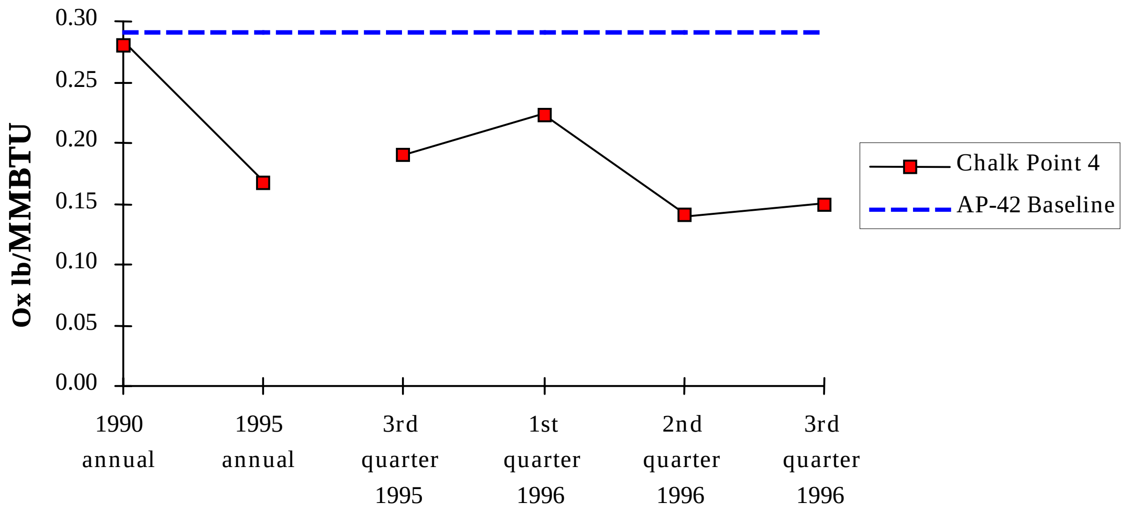


With the exception of CEMS reported rates during the 3rd quarter of 1995, Unit 11 at R.P. Smith with low NO_x burners has demonstrated operation at a NO_x emission rate of 0.41 lb / MMBTU. This emission rate is 28% lower than the AP-42 baseline calculated rate for tangentially coal-fired boilers of 0.57 lb / MMBTU. The two units at Morgantown have been consistently exceeding the NO_x baseline emission level, operating at 0.66 lb / MMBTU. However, PEPCO reported that actual pre- NO_x control emissions were about 1 lb / MMBTU because of high heat release rates. The vendor's (Combustion Engineering) guarantee for the low NO_x burners (level 3 burners) is 0.66 lb / MMBTU, so both of the units at Morgantown are operating as expected. Using the baseline rate provided by PEPCO, NO_x emissions from the Morgantown units have decreased by 34% since the installation of low NO_x burners. However, when compared with emissions suggested by AP-42 and the emission rates required by MDE as presumptive RACT, the emissions are relatively high.

The remaining unit in Maryland with NO_x control is Chalk Point Unit 4, a tangentially-fired boiler, which burns primarily oil. As indicated in Figure 3-4, this unit is operating at a significantly lower NO_x emission rate than is expected for uncontrolled tangentially oil-fired boilers. Prior to the installation of low NO_x burners, emission data reported by PEPCO shows that this unit operated at a NO_x emission rate of 0.3 lb / MMBTU; low NO_x burners have provided a reduction of 38% in NO_x emissions. The current emission rate is meeting the presumptive NO_x RACT limit for this unit of

0.25 lb / MMBTU, as expected per the NO_x RACT plan submitted by PEPCO.

Figure 3-4 Tangential Oil-Fired Low NO_x Burners

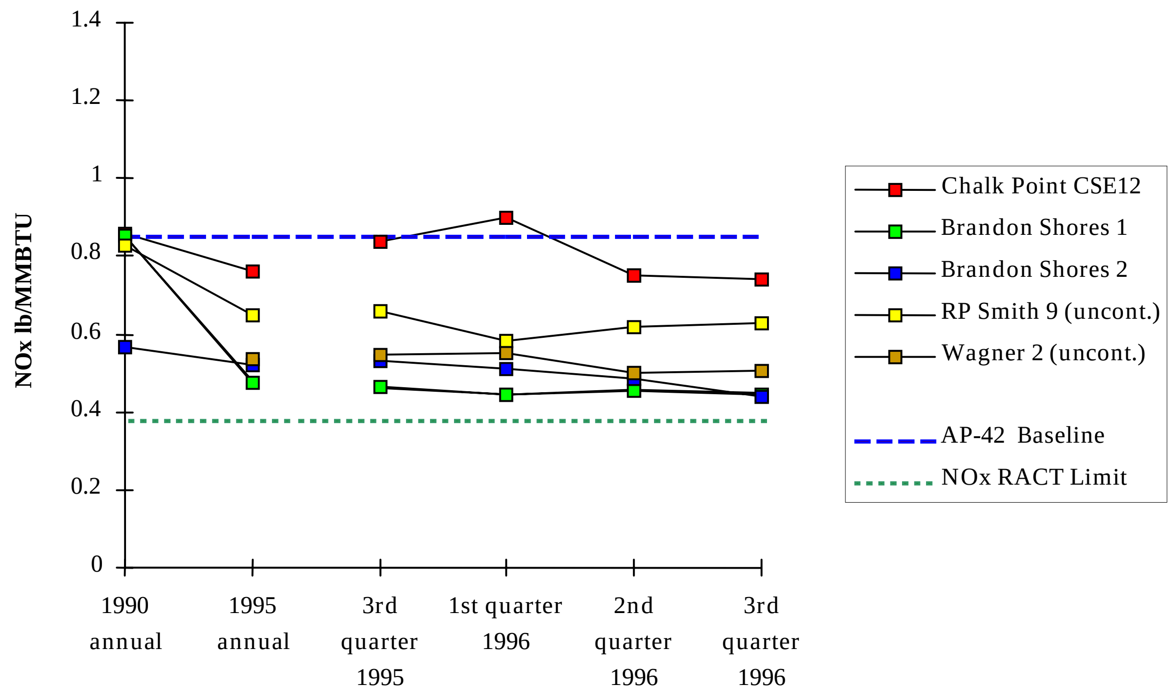


3.3 EFFECTIVENESS OF NO_x CONTROL COMPARED TO OTHER UNCONTROLLED UNITS

This section describes how the units with NO_x control equipment in Maryland compare with similar uncontrolled units. We also provide comparisons of the NO_x emissions for controlled units versus the NO_x RACT emission limits suggested by MDE to illustrate how these units are operating relative to the reductions called for by RACT regulations.

NO_x emissions from all coal wall-fired units operating in Maryland, controlled or uncontrolled, are shown in Figure 3-5. The 1990 NO_x emission rates for the Wagner units are not included in Figure 3-5 because accurate data was not available. None of the units, controlled or uncontrolled, appear to be meeting the Maryland presumptive NO_x RACT limit of 0.38 lb / MMBTU, but have met the newly established alternative NO_x RACT limits in applicable operating permits. Unit 3 at Wagner emits at levels that are twice some of the other units and even exceeds the level predicted by AP-42. The uncontrolled wall-fired unit, R.P. Smith Unit 9 is, on average, operating at NO_x emission rates comparable to the controlled units.

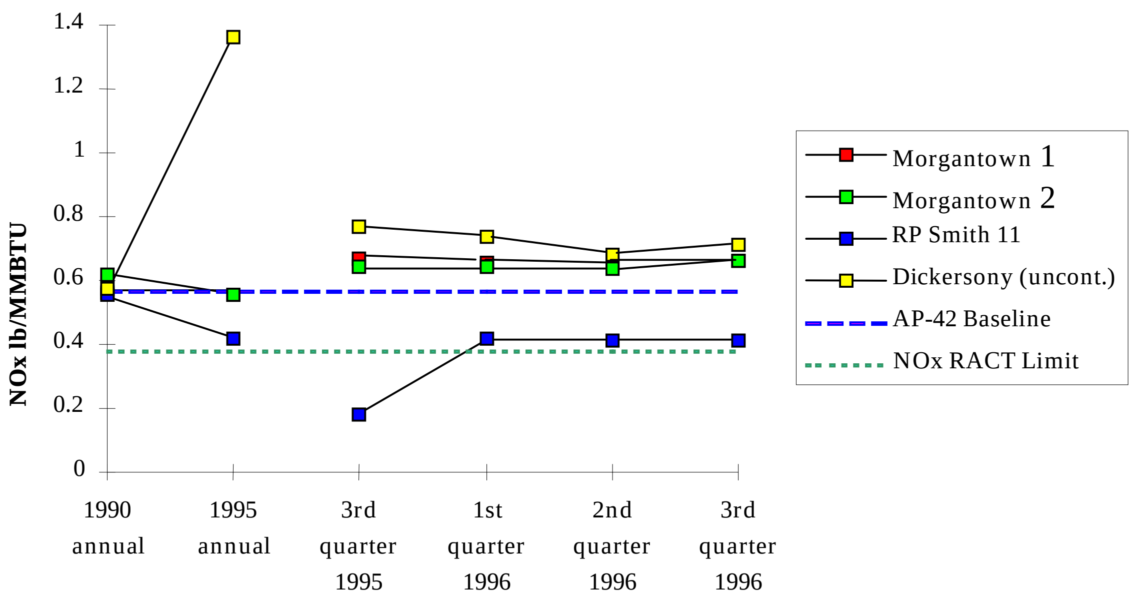
Figure 3-5 Coal Wall-Fired Burners



BGE noted that a 50% reduction in NO_x emissions was expected at Wagner Unit 2 after it was retrofitted with low NO_x burners in 1995. However, problems with excessive particulates and unburned carbon have resulted in actual reductions of 20-30%. BGE is considering rebuilding Wagner Unit 3 with a low NO_x burner.

Figure 3-6 presents information on the tangential coal-fired boilers, as previously shown in Figure 3-3, with the addition of the uncontrolled units at Dickerson. Dickerson has three similar units that exhaust through a common stack. Evaluation of the data presented in Figure 3-6 indicates that on average, the NO_x emission rate from Dickerson is similar to both units at Morgantown. In its NO_x RACT proposal, PEPCO submitted an alternative NO_x limit for the each of the units at Dickerson of 0.53 lb/MMBTU. From the CEMS data, assuming that each of the units are operating equally, it does not appear that Dickerson is meeting this alternative RACT level. Since the three units at Dickerson exhaust through a common stack, monitoring equipment would be needed on the vent from each unit to determine the exact emission rate from each. However, recent conversations with MDE indicate that PEPCO is utilizing an emissions averaging approach to NO_x RACT compliance. The higher NO_x emission rates at Dickerson are therefore offset by lower emission rates at other facilities operated in Maryland such as Chalk Point.

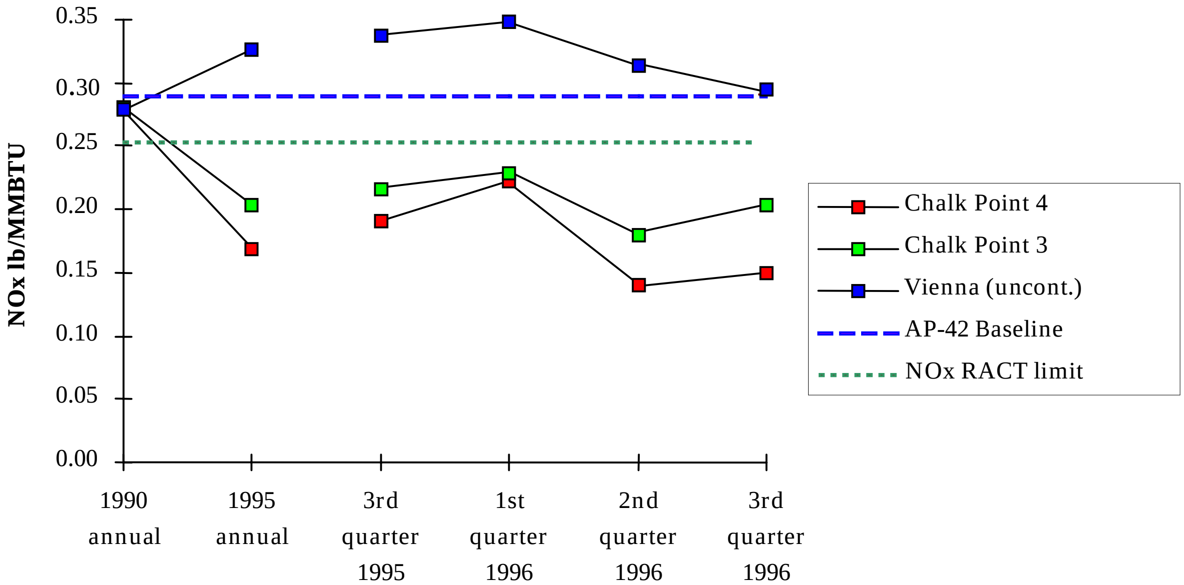
Figure 3-6 All Tangential Coal-Fired Boilers



In general, none of the tangentially coal-fired units, either controlled or uncontrolled, have demonstrated the ability to operate at NO_x emission rates below the presumptive RACT limits established by MDE. However, each has shown in 1995 and 1996 to have operated below the limits for NO_x defined as RACT by MDE in applicable operating permits.

Figure 3-7 presents the NO_x emission rates for tangential oil-fired boilers. Uncontrolled units at Chalk Point and Vienna are included in the figure for comparison. Unit 3 at Chalk Point is operating below the NO_x RACT presumptive limit, similar to Unit 4. Chalk Point Unit 3 is the same size boiler as Unit 4 (but six years older), yet is achieving nearly the same NO_x emission rate without the use of a low NO_x burner. Vienna, a much smaller unit, is emitting NO_x at a rate twice that of Chalk Point 4.

Figure 3-7 Tangential Oil-Fired Boilers



Figures 3-8 through 3-10 provide NO_x emission information for boiler types operated in Maryland with NO_x control. The cyclone boilers of C.P. Crane are shown in Figure 3-8, the wall oil-fired boilers at Gould Street and Wagner are shown in Figure 3-9, and Maryland's sole gas-only burner, Riverside, is presented in Figure 3-10. The emissions are presented for comparison with the applicable Maryland presumptive NO_x RACT limit.

Figure 3-8 Cyclone Coal-Fired Boilers

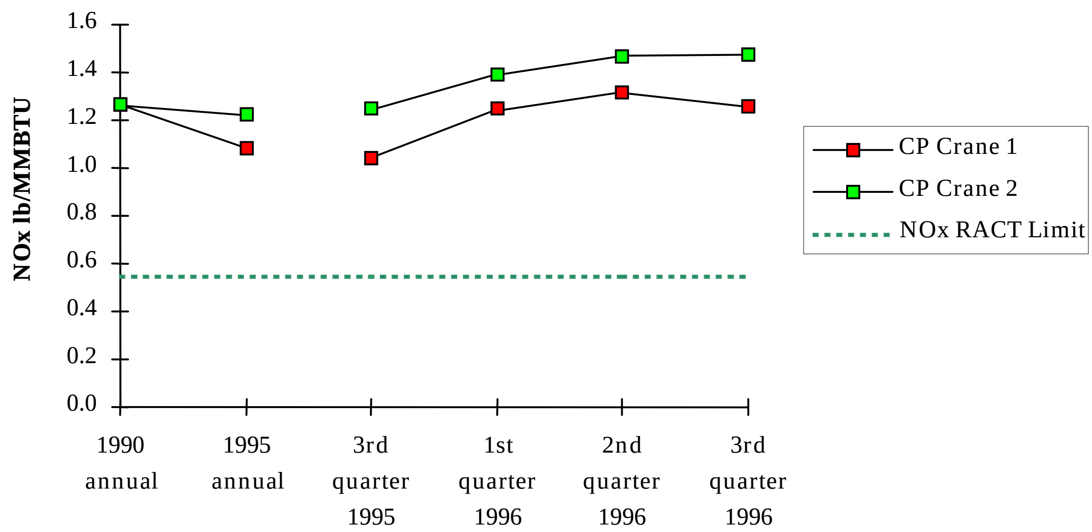


Figure 3-9 Wall Oil-Fired Boilers

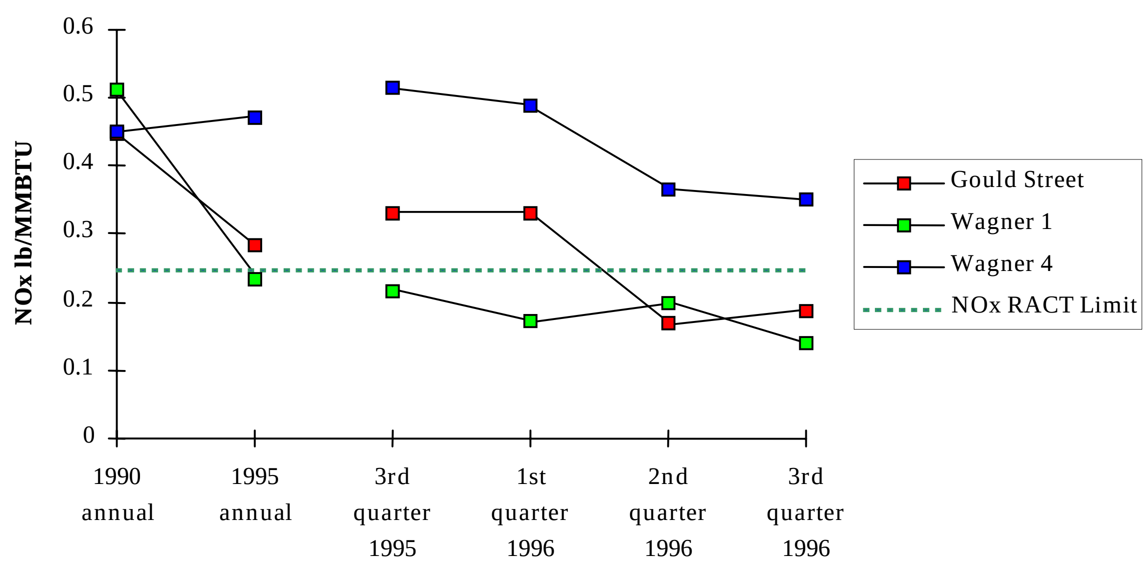
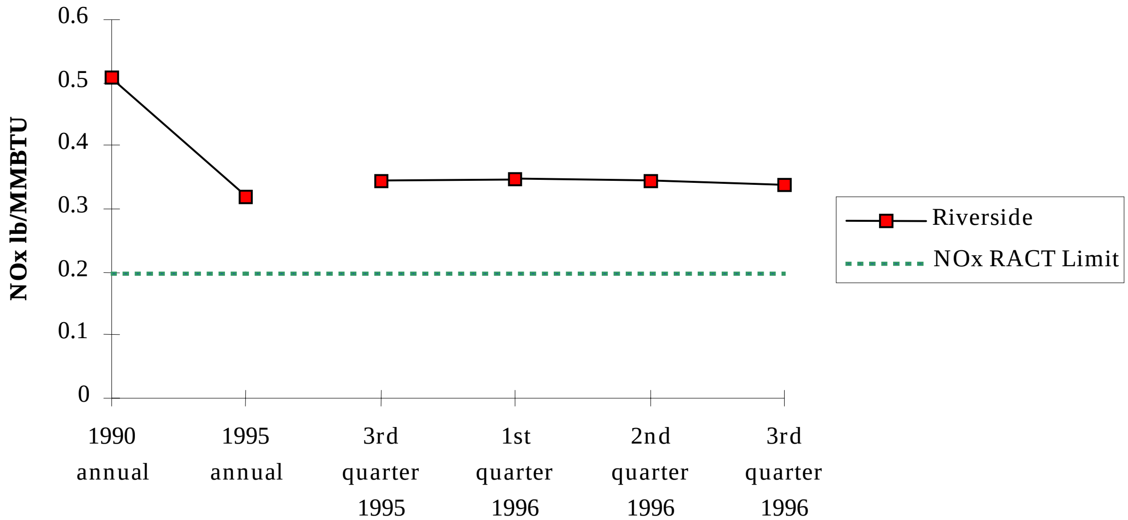


Figure 3-10 Wall Gas-Fired Boiler



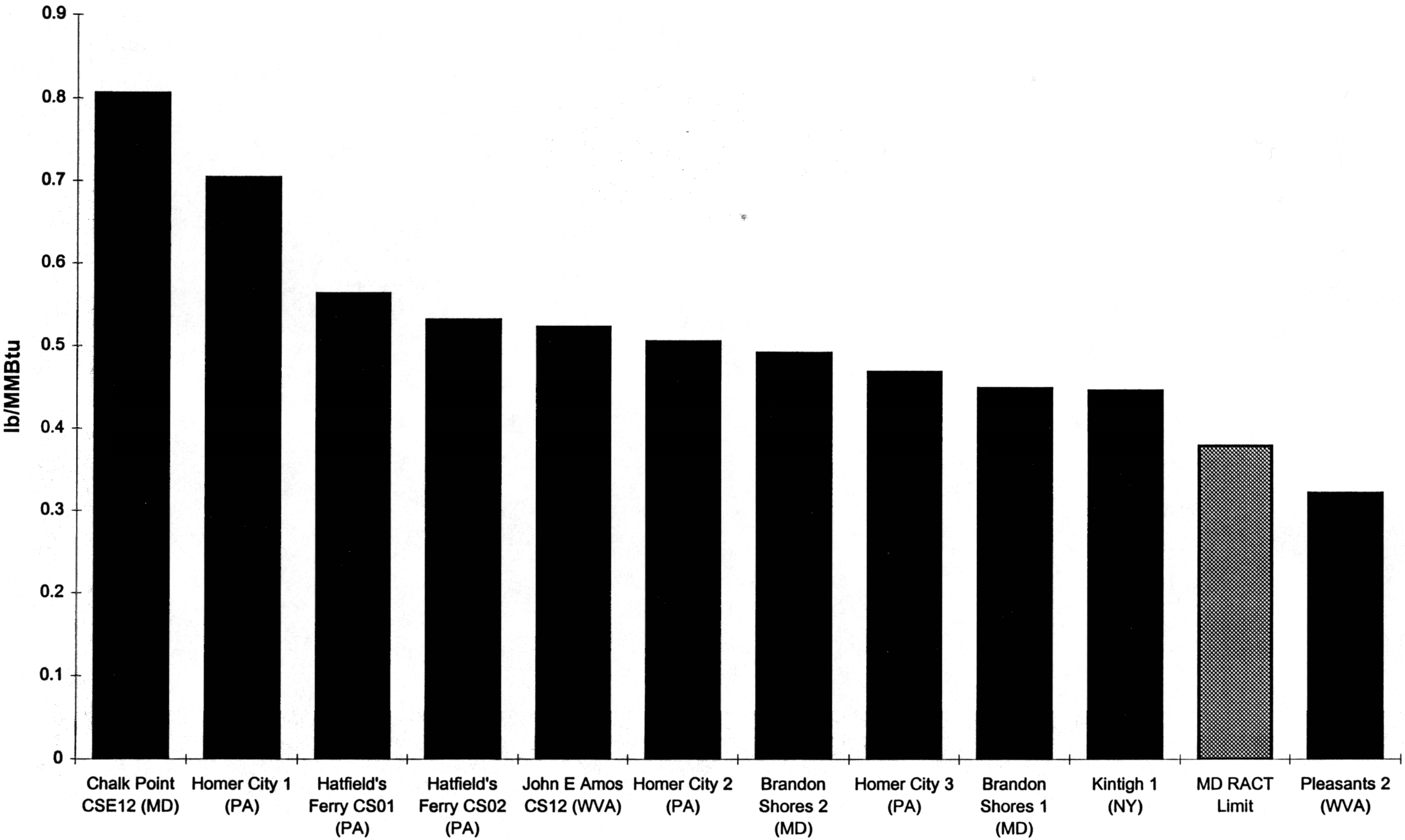
3.4 COMPARISON WITH OUT-OF-STATE UNITS

3.4.1 Coal Burning Units

Wall-fired low NO_x coal burners operating in Maryland, when compared with similar sized wall-fired units equipped with low NO_x burners from nearby states, typically perform on a comparable level, as shown in Figure 3-11. The Chalk Point burners show an average NO_x emission rate of about 0.8 lb / MMBTU. The two units at Brandon Shores with low NO_x technology average approximately 0.5 lb / MMBTU, other coal-fired units in the region range from 0.32 to 0.70 lb / MMBTU. Emission rates averaged from the 4th quarter in 1995 through the 3rd quarter in 1996 as reported in ETS submittals to EPA were used for the comparison of these coal-burning, wall-fired low NO_x burners. All of the units presented in Figure 3-11 generate greater than 600 MW per unit. The presumptive NO_x RACT limit suggested by Maryland is also included for comparison.

All of the units presented in Figure 3-11 incorporate low NO_x burners as NO_x control (Chalk Point operates low NO_x burners with overfire air). Similar units employing low NO_x coal burners in Pennsylvania (Elrama, Bruce Mansfield, Martins Creek, and Sunbury), which have NO_x emissions ranging between 0.42 to 0.60 lb / MMBTU, appear to provide no improvement above low NO_x without overfire air. While overfire air

Figure 3-11 Average NOx Emission Rates from Wall Fired Low NOx Burners (Coal)



alone as NO_x control is generally not employed, Danskammer, a power plant in New York with overfire air, emits NO_x from two units at an average of 0.37 lb / MMBTU.

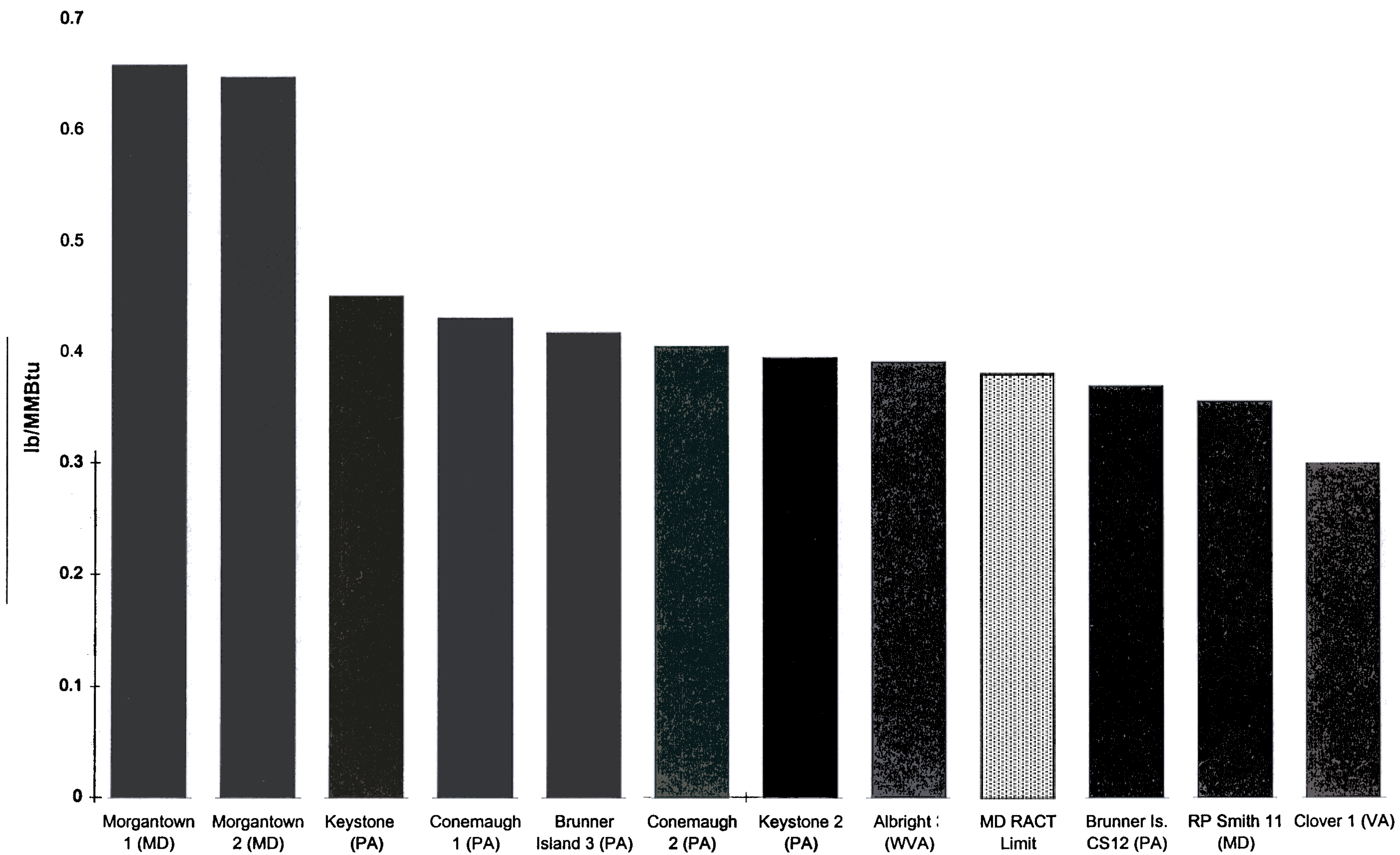
Conversely, the high emission levels from the tangentially-fired units at Morgantown are not reflected by other coal burning tangentially-fired low NO_x burners in the region. Morgantown, at approximately 0.65 lb / MMBTU, emits at a greater rate than all other similar units in the local region (Figure 3-12). However, only a few of these units are meeting the presumptive RACT level of 0.38 lb / MMBTU suggested by the State of Maryland (many other states did not establish a presumptive RACT emission limit, such as 0.38 lb / MMBTU, as Maryland did). While the low NO_x unit at R.P. Smith is meeting presumptive RACT (at 0.355 lb / MMBTU), it is also the smallest unit (75 MW) included in this comparison.

3.4.2 Oil/Gas Burning Units

A similar analysis was conducted for oil and gas burning units with NO_x control in the surrounding states. Among the tangential gas-fired units (all with overfire air), average emissions range from 0.03 to 0.10 lb NO_x / MMBTU. These emissions rates are below those reported by Maryland's only gas-fired unit reporting CEMS data, BGE's Riverside unit with an average of 0.34 lb NO_x / MMBTU.

Other tangential oil-fired units outside of Maryland with NO_x control (all units analyzed employed overfire air) emit between 0.16 and 0.18 lb NO_x / MMBTU. These emissions are similar to those at Chalk Point 4 and are below Maryland's suggested RACT level of 0.25 lb / MMBTU for oil units. One oil-burning unit in New York state (Charles Poletti) with low NO_x burners and overfire air has reported average NO_x emissions of 0.19 lb / MMBTU, for comparison.

Figure 3-12 Average NOx Emission Rates from Tangentially Fired Low NOx Burners (Coal)



4.0 IMPACTS OF FUTURE NO_x REDUCTION REQUIREMENTS

Power plants in Maryland will be subject to additional NO_x control requirements in the future, beyond those mandated by NO_x RACT requirements. Several regulatory programs have been promulgated or are under development as a result of the amendments to the CAA in 1990. Some of these regulations apply specifically as a result of ozone NAAQS compliance under Title I of the CAA and some apply to utility sources as a result of emissions reductions for acid rain units regulated under Title IV of the CAA.

4.1 BEYOND RACT REGULATORY REQUIREMENTS

Title I of the CAA allows EPA to require additional reductions in NO_x emissions if the initial round of RACT does not provide reasonable rate of progress for compliance with the ozone NAAQS. In addition, EPA established a new ozone NAAQS in July 1997 that may require additional NO_x control.

There are several initiatives underway for ozone NAAQS compliance that will impact NO_x emissions from utility sources in Maryland. The OTC was established to assess the degree of interstate transport in the OTR and to make recommendations for bringing the OTR into compliance with the ozone NAAQS. On 27 September 1994, Maryland was a signatory of a Memorandum of Understanding (MOU) developed by the OTC that committed the states within the OTR to NO_x emission reductions of up to 75% by the year 2003 through a market based cap-and-trade system. The MOU specified that the overall NO_x reductions would be achieved in two phases: reductions in ozone season NO_x emissions of 65% below calendar year 1990 levels by the year 2000, and an additional 10% reduction from 1990 levels by the year 2003. Each state has the flexibility to develop the requirements for emission sources to achieve these overall NO_x reductions. The Maryland NO_x budget program codified in COMAR 26.11.27 and 26.11.28 was developed in July 1999 and focuses on requirements for NO_x emission reductions from utility sources.

Within the last few years, EPA has recognized that the ozone compliance problem in the Northeastern United States is not a local issue, and that transport of ozone occurs from sources upwind into downwind states affecting ozone NAAQS compliance. In a March 1995 policy memorandum, EPA indicated that ozone transport into the OTR may have impacts on NAAQS attainment. As a result, the Ozone Transport

Assessment Group (OTAG) was created in May 1995 to conduct studies to evaluate the transport of ozone and ozone precursors in the eastern United States. OTAG conducted large-scale photochemical grid modeling to understand the impacts of varying NO_x and VOCs emission reductions on ozone formation within a 37-state domain. The results of the OTAG assessments were summarized in a June 1997 report to EPA. OTAG provided recommended control strategies that were shown to have beneficial impacts for ozone NAAQS compliance within the OTAG domain.

Using information developed by individual states, through the OTAG process, and by the Agency itself, EPA has recently imposed significant new NO_x reduction requirements to improve ozone pollution. The new Regional NO_x Emissions Reduction rule or "NO_x SIP Call", announced by EPA Administrator Carol Browner on September 24, 1998, will affect sources in 22 Midwestern and Eastern states and the District of Columbia. Under the rule, all affected states will have to develop new, more stringent plans to reduce NO_x, and to implement those plans by May 2003. The rules require summertime (or "ozone season") reductions in NO_x emissions of about 28% (1.2 million tons of NO_x) across the 22 states and Washington, D.C.

The rule does not mandate which sources must reduce NO_x emissions. In fact, states are provided flexibility in how to achieve their NO_x reduction targets. However, because utilities and other combustion sources are among the largest stack sources of NO_x, combustion sources are targeted for significant NO_x reductions.

To provide an opportunity for more cost-effective compliance, the new rule allows states to establish NO_x pollutant trading programs as part of the NO_x compliance plan. In addition to individual state trading programs, EPA is working with states to establish a multi-state "cap and trade" program for utility and other large combustion sources to reduce NO_x. As part of its trading program, EPA will allow facilities that "over-control" to sell emission reductions to other facilities that cannot reduce as quickly or as cost-effectively. The program will provide "bonus" credits to sources that reduce pollutants early. Sates are developing their NO_x reduction plans in response to the new rule.

It is unclear at this time how the revised NAAQS for ozone promulgated by EPA in July 1997 will impact utility sources in Maryland. Few studies have been conducted to date on the contribution of NO_x emissions to ozone NAAQS compliance as the standard changed from 120 ppb (1-hr average) to 80 ppb (8-hr average). In a decision announced in May 1999, the US Court of Appeals for the District of Columbia Circuit blocked

EPA's authority to implement the new 8-hour ozone standard, which further complicates this issue.

Although not specifically driven by ozone NAAQS compliance, regulations developed to meet the mandates of Title IV of the CAA (acid rain provisions) require NO_x emission reductions based on boiler types. Boilers were divided into two groups: Phase I units and Phase II units. Phase I units include coal burning dry wall, wall-fired, and tangentially-fired boilers. The remaining boiler types were grouped into the Phase II category. The Title IV limits by unit are summarized in Table 4-1. To meet the applicable emissions limit, the regulations specify technology that must be implemented for each unit type. For comparison, the presumptive NO_x RACT emission rate limits required by regulations developed under Title I are summarized in Table 4-1.

Table 4-1 CAA Title IV NO_x Emission Limits Applicable to Maryland Utility Units

Phase I or II Unit[1]	Unit Type	Compliance Date	Annual Average NO_x Emission Limit (lb/MMBTU)	Technology Required[2]	Maryland NO_x RACT Emission Limit[3] (lb/MMBTU)
I	Coal burning, dry bottom, wall-fired	1 January 1995	0.50	Low NO_x burners	0.38
I	Coal burning, tangentially-fired	1 January 1995	0.45	low NO_x burners	0.38
II	Tangentially-fired	1 January 2000	0.45	Retrofit or best Phase I controls	0.25
II	Dry bottom, wall-fired	1 January 2000	0.38	Retrofit or best Phase I controls	0.25
II	Cyclone	1 January 2000	0.94	Retrofit or best Phase I controls	0.55

(1) Phase I limits promulgated 13 April 1995 and Phase II limits promulgated on 19 December 1996.
(2) Units may also demonstrate compliance through emissions averaging, alternative limits, or compliance extensions.
(3) Maryland NO_x RACT limitations from COMAR 26.11.09.08.

NO_x RACT limits are more stringent than the acid rain limits. However, further evaluation of the Title IV standards provides insight into future NO_x reductions that may be required by utilities operating in Maryland. As noted in previous sections of this report, many utility sources cannot achieve the presumptive RACT limits. Alternative NO_x emission levels have been defined in operating permits for these units. In many cases, these alternative emission rates exceed those that will be required to be installed to achieve the Title IV compliance requirements for Phase II units listed in Table 4-1. Therefore, additional NO_x reductions will be required for these units under the acid rain provisions, regardless of the status of RACT.

4.2 AVAILABLE CONTROL TECHNOLOGIES FOR ADDITIONAL EMISSIONS REDUCTIONS

Many of the utility sources operated in Maryland found that add-on control to reduce NO_x emissions were not cost-effective, and therefore were not proposed and implemented as RACT. Even those sources where low NO_x burners or overfire air were utilized to meet RACT did not result in emissions reductions sufficient to meet the emission rates required by the OTC MOU. As such, these sources will have to evaluate commercially-available technologies and retrofit existing equipment to achieve NO_x emission reductions.

There are numerous sources of information regarding the available NO_x emissions reduction technologies that can be utilized for both utility boilers and combustion turbines (OTAG, 1996; PPRP, 1993a; PPRP 1993b; EPA, 1992). It is not the intent of this document to reiterate this information. However, it is anticipated that more units will be retrofitted with low NO_x burners and overfire air, or add-on control systems such as selective catalytic reduction (SCR) and selective non-catalytic reduction (SNCR) technologies will be employed to meet the overall NO_x reductions required to meet regulatory compliance. These technologies are gaining widespread acceptance as more systems are installed.

The varying types of utility sources operating in Maryland (wall-fired, tangentially-fired, cyclone, cell burners) utilizing various fuels (coal, oil, and natural gas) provide additional complication to utility sources in the selection of appropriate technologies in a cost effective manner to achieve both Title I and Title IV NO_x emission limits. Several factors must be considered in selection of the appropriate technology, including: fuel composition; availability of secondary fuels; boiler design; operating or duty cycle of the boiler; space constraints and limitations; and commercial availability and viability of control technologies. Also, as in the case with PEPCO, a strategy must be developed for all units that apply the emissions averaging approach, such that overall NO_x reductions are sufficient to meet regulatory requirements in a cost-effective manner.

It is clear that additional NO_x emissions reductions beyond the 30-40% experienced by the Maryland utility sources is required to comply with "beyond RACT" emission limits.

4.3 BGE BEYOND RACT APPROACH

BGE provides a good example of the types of planning that utilities have conducted to address the anticipated additional emissions reductions that are required in Maryland to meet both Title I and Title IV requirements. BGE has implemented modifications, or has plans for modifications, to several units. This listing is not inclusive, but rather provides a description of the types of alternatives, and emissions reductions that are anticipated to be achieved to maintain compliance with current and future Maryland and federal NO_x emission regulations.

In 1996, Gould Street Unit 3 was switched from oil to dual natural gas- and oil-firing to allow the use of natural gas during the ozone season. The installation of a low NO_x burner was also completed at this time. The purpose of the modification, according to BGE personnel (BGE, 1997b), was economics, allowing BGE to use less expensive fuel over the course of the year.

BGE has developed several strategies to address future NO_x reduction requirements for the Brandon Shores and C.P. Crane units. BGE is plans upgrade the Brandon Shores units to install SCR control technology. In addition, BGE retrofit both Crane Units 1 and 2 with gas reburn technology (PPRP 1999).

Wagner Unit 3 was unique because it was one of the few cell-burners operating in the United States. There have been no demonstration projects to date that have resulted in successful NO_x reductions for cell burners. In early 1999, BGE converted the unit to a wall-fired boiler equipped with LNB and OFA (PPRP 1999).

Fuel switching has also been implemented at two units: Wagner Unit 1 uses natural gas for a minimum of 70% of its total heat input during the ozone season; and Riverside Unit 4 provides 100% of its generation during the ozone season through the combustion of natural gas.

5.0 *SUMMARY AND CONCLUSIONS*

Based on the review of the NO_x RACT proposals submitted by Maryland utilities to address regulatory requirements, a review of the available NO_x emissions data for both Maryland utilities and similar utility units operating in the nearby region, and discussions on unit operating experience with utility personnel, the following observations are made:

- In most cases, the four utilities with steam generating units in Maryland indicated in their NO_x RACT proposals that the presumptive NO_x RACT limits established by MDE could not be met either for technical or economical feasibility reasons.
- Even with low NO_x burners, few utility units operating in Maryland have been able to meet MDE's presumptive NO_x RACT limits. However, emissions data from 1995 and 1996 show that all of the plants that have been issued operating permits have been able to meet permitted NO_x RACT emission limits.
- Alternative emission limits to meet NO_x RACT were proposed for every affected unit in Maryland except for PEPCO's Chalk Point Unit 4, which was already equipped with low NO_x burners.
- Low NO_x burners were the only control technology proposed and implemented for NO_x RACT compliance. Nine of the 19 operating units in Maryland currently utilize low NO_x burners; the remainder have no add-on control or burner modifications to reduce NO_x emissions.
- The average NO_x emission reductions demonstrated by Maryland units retrofitted with low NO_x burners is in the range of 35-40% from 1990 baseline levels (where baseline assumes emissions at AP-42 rates).
- Low NO_x burners appear to be most efficient in reducing NO_x on tangentially coal-fired units, specifically on the Morgantown and R.P. Smith units.
- Few operating units in Maryland, Pennsylvania, West Virginia, or Virginia have reported NO_x emissions in 1995 or 1996 that have met the Maryland presumptive NO_x RACT emission limits.
- Units operating in surrounding states similar to those operating in Maryland (based on size, boiler type, fuel combusted and fitted with low NO_x burners) have reported similar NO_x emissions and emissions reductions as a result of low NO_x burner installation.
- Additional NO_x emissions reductions will be required to meet additional Title I and Title IV limits that go beyond those initially

required to meet NO_x RACT. Combustion modifications such as low NO_x burners and overfire air, and add-on control technologies including SCR and SNCR are anticipated to be employed by more sources to achieve the NO_x emissions reductions required in future years.

Recent and future regulatory and policy developments will necessitate additional NO_x reductions beyond those required by RACT in the coming years. These reductions may require the implementation of add-on control, the buying and selling of emission credits under a cap-and-trade program, or a combined of the two.

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